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Energy Efficiency Associated with Poultry House Lighting[1]

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INSIDE

Introduction

Solid sidewall poultry housing has created a situation where lighting is now a major cost center. Loss of natural daylight means any light birds receive is now provided artificially with bulbs, which have an energy cost associated with them. Currently, incandescent, fluorescent, high pressure sodium, cold cathode and others lighting options are available to poultry producers but choosing the correct one can be difficult. Since April 2006, the Applied Broiler Research Farm (ABRF) has evaluated the energy usage associated with different light sources.

Energy Use and Cost for Lighting

The ABRF sub-meters electricity used for lighting through a separate electric meter that allows accurate measurement of lighting kilowatt hour electricity usage. After farm renovations were completed in April 2006, all 4 houses had 2 rows of 60-watt incandescent lights above the feed lines and a center row of brood lights that was 75-watt incandescent. Houses 1 and 2 have a total of 75 bulbs (42 dimmable lights plus 33 brood lights) while houses 3 and 4 have a total of 90 bulbs (50 dimmable lights plus 40 brood lights). Prior to the start of the December 2006 flock, the 60-watt incandescent dimmable lights in house 3 were replaced with 8-watt dimmable cold cathode bulbs with a 2700 Kelvin rating. Incandescent brood lights were not changed. Kilowatt hour usage for lighting during the December 2006 flock was 1,790 hrs, 1,740 hrs, 705 hrs, and 2,054 hrs for houses 1 through 4, respectively. Energy cost associated with this usage was $107, $104, $42, and $123 for houses 1, 2, 3, and 4, respectively. There was no difference in average weights, feed conversion or mortality for each of the houses.

A second flock was placed and bird weights (as measured by in-house bird scales) in the 2700 Kelvin light house began to decline once the brood lights were turned off. The brood lights were turned back on until birds were 5 weeks old to help stimulate growth and this resulted in less electricity savings difference. It was determined that the current strain of birds were more sensitive to light intensity and the 2700 Kelvin cold cathode only provided 0.35 to 0.50 ft-candles at the feed line compared to 0.5 ft-candles in the incandescent houses. In addition, the 2700 Kelvin cold cathode bulb gave off an orange tint similar to a 60- or 75-watt incandescent bulb.

To help address these concerns, we began working with an Arkansas lighting vendor (Precision Lighting Systems, Inc.; Hot Springs, AR). Prior to the May 2007 flock, the incandescent dimmable lights in house 4 were replaced with 8-watt cold cathode bulbs with a 4000 Kelvin rating. These bulbs have a slight bluish tint compared to the orange tint of the 2700 Kelvin bulb; and, are able to deliver 0.50 ft.-candles of light at the feed line. Therefore, the May 2007 flock consisted of all incandescent bulbs in houses 1 and 2, incandescent brood lights and

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[1]Mention of trade names does not constitute endorsement by the University of Arkansas Division of Agriculture and does not imply their approval to the exclusion of other products or vendors that may be suitable.

. . . helping ensure the efficient production of top quality poultry products in Arkansas and beyond.

2700 Kelvin 8-watt cold cathode dimmable lights in house 3, and incandescent brood lights and 4000 Kelvin 8-watt cold cathode dimmable lights in house 4. The kilowatt hour usage for lights during the flock was 2,527 hrs, 2,521 hrs, 1,852 hrs and 1,154 hrs for houses 1, 2, 3, and 4, respectively. Cost associated with this usage was $152, $151, $111, and $69 for houses 1 through 4, respectively.

For the February and May 2007 flocks it was necessary to leave the incandescent brood lights on in house 3 until 5 weeks of age in an attempt to stimulate the birds to eat more feed with an increased light intensity. However, house 4 with the 4000 Kelvin cold cathode and a 0.5 ft-candle light intensity at the feed line did not have problems with decreased weight gains. The conclusion from this evaluation was that the 4000 Kelvin cold cathode would provide adequate light intensity for proper bird growth and feed consumption while providing producers with an energy efficient lighting source.

Lighting sources for the July 2007 flock was as follows: House 3 – 2700 Kelvin cold cathode lights were changed to 4000 Kelvin cold cathodes; Houses 3 and 4 – all incandescent brood lights were replaced with 15-watt fluorescent above the feed lines and 30-watt fluorescent down the center row. For this flock, kilowatt hour usage for lighting was 2,744 hrs, 2,726 hrs, 634 hrs, and 645 hrs for houses 1 through 4, respectively. Cost associated with this usage was $190, $191, $44, and $45 for houses 1 through 4, respectively. Prior to the October 2007 flock, all incandescent lights in house 2 were replaced with 23-watt dimmable fluorescent bulbs. Kilowatt hour usage for lighting was 1,722 hrs, 478 hrs, 502 hrs, and 535 hrs, for houses 1 through 4, respectively. Energy cost was $122, $33, $35, and $37 for houses 1 through 4, respectively. Prior to the February 2008 flock, all incandescent lights in house 1 were replaced with 23-watt dimmable fluorescent bulbs. Kilowatt hour usage for lighting on this flock was 561 hrs, 590, hrs, 474 hrs, and 453 hrs for houses 1 through 4, respectively. Energy cost for lighting was $39, $41, $33, and $32 for houses 1 through 4, respectively.

Switching to energy efficient bulbs has dramatically cut energy usage and costs associated with lighting at the ABRF. Immediately after farm renovation (April through November 2006) when all 4 houses were using 60- and 75-watt incandescent bulbs, kilowatt hour usage for lights on the farm averaged 9,432 hrs at a cost of $660 per flock over a 4-flock period. From February through August 2008, with houses 1 and 2 using 23-watt dimmable fluorescent bulbs and houses 3 and 4 using a combination of 15- and 30-watt fluorescent brood lights and 8-watt cold cathode grow lights, kilowatt hour usage on the farm for lights averaged 1,996 hours at a cost of $140 for a 3-flock period. Thus, savings after switching to energy efficient lighting have averaged 7,436 kilowatt hrs and $520 per flock at the ABRF. Bulb failures have been somewhat less on the cold cathode vs. the 23-watt dimmable fluorescent; averaging approximately 1 to 2 bulbs every other flock for the cold cathode and 2 to 3 per flock on the dimmable fluorescent. Kilowatt hour usage of each individual house for incandescent and energy efficient lighting is presented in figures 1 and 2, respectively. Cost of incandescent and energy efficient lighting for each house is presented in figures 3 and 4, respectively.

There are a number of energy efficient alternatives to incandescent lighting now available although all are more expensive initially than incandescent bulbs. The cold cathode bulbs we are currently using sell for about $9 per bulb but cheaper options are available when bulk purchasing the bulbs. The 23-watt dimmable fluorescent bulbs sell for about $7 per bulb. However, life expectancy of the cold cathodes is approximately 25,000 hrs as compared to an incandescent bulb which has an estimated life span of approximately 2,000-5,000 hrs depending on the quality of the bulbs of these bulbs is much greater than that of an incandescent bulb and it is much less expensive to burn an 8- or 23-watt bulb than it is a 60- , 75-, or 100-watt bulb. So think long-term savings, not simply initial up-front bulb cost.

Summary

Solid sidewall housing has many advantages for producers. However, one disadvantage is the increased electricity for lighting. At present, lighting is an area offering producers much potential in terms of energy conservation. However, it is critical to provide birds with the correct light intensity if expected performance levels are to be met. This can now be done with a variety of different lighting methods (incandescent, fluorescent, cold cathode, sodium vapor, etc.). Producers should give serious consideration to lighting alternatives that conserve energy and offer long-term savings.

Figure 1. Average Kilowatt Hour Usage for Lights During Flocks 87-90 at the ABRF.

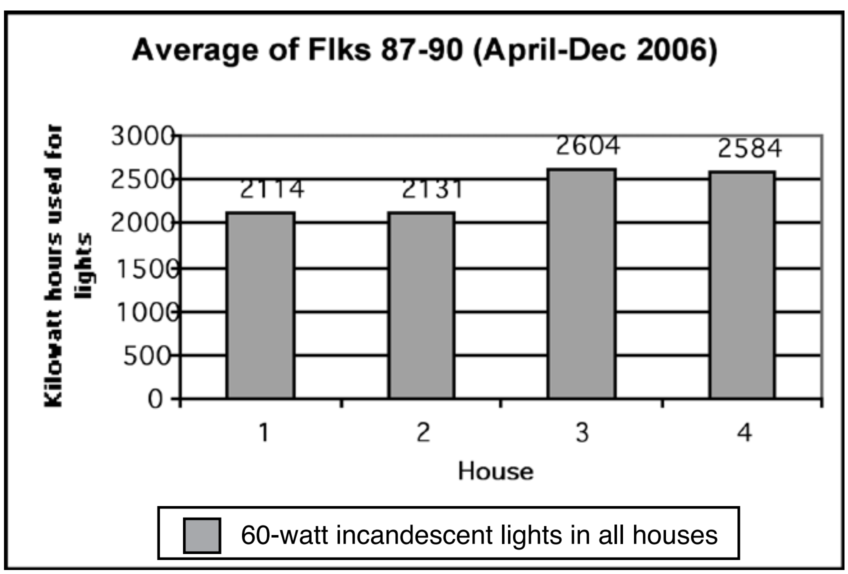


Figure 2. Average Kilowatt Hour Usage for Lights During Flocks 97-99 at the ABRF.

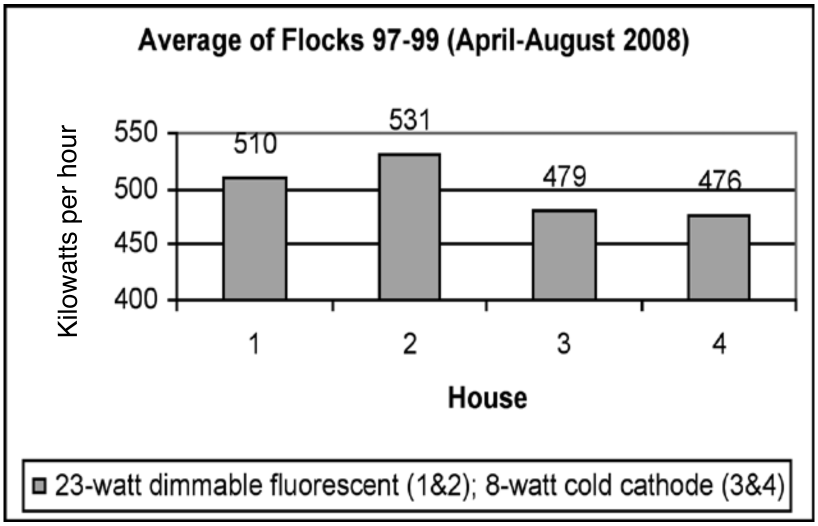


Figure 3. Cost of Electricity Used for Lighting During Flocks 87-90 at the ABRF.

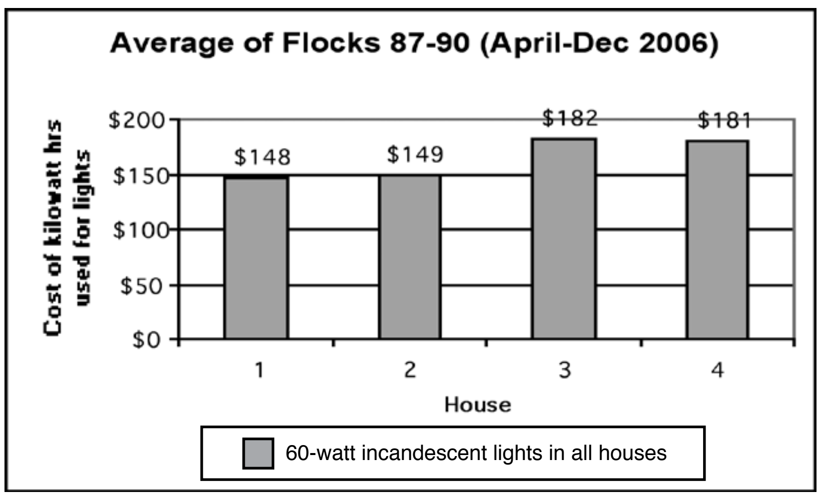
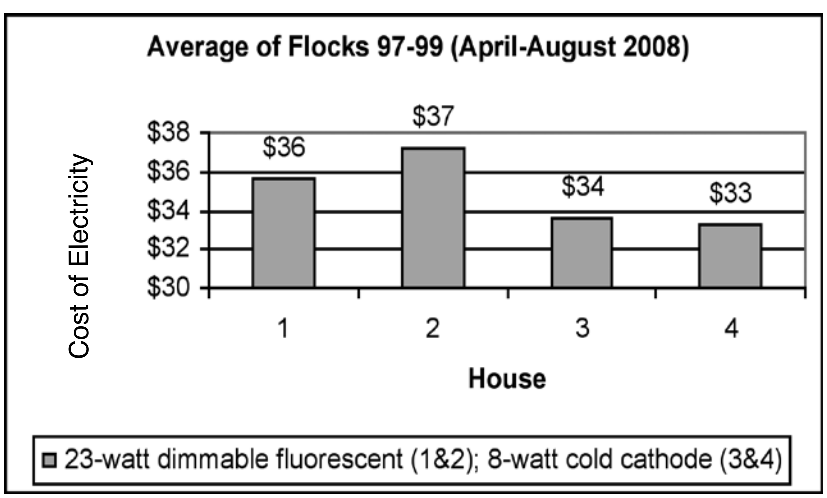


Figure 4. Cost of Electricity Used for Lighting During Flocks 97-99 at the ABRF.



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Evaluation of Water Acidification Products

Introduction

Acidification products are often used as water line cleaners in poultry houses. However, recent field observations indicate that utilizing acids in water systems which are heavily contaminated with microbes could be more harmful than helpful in water sanitation programs. The following lab test was conducted to evaluate the effects of different types of acidification products on general microbial levels in "dirty" water. In addition, the goal was to determine if acid products might vary in their ability to reduce microbial content in water at different pH levels.

Materials and Methods

In this test, four water acidification products (acidified copper sulfate, citric acid (food grade), citric acid (Russell), and sodium bisulfate) were evaluated for their ability to reduce aerobic bacterial, yeast and mold counts in dirty water. Stock solutions of acidified copper sulfate or sodium bisulfate were prepared by mixing 453.6 g with 2 gal of water. Citric acid stock solutions were made by combining 453.6 g of food grade or Russell citric acid with 1/2 gal of water. Each acidification product was tested at pH values of 4 and 6, resulting in a total of 9 treatments (counting controls).

Water used in this test was obtained from an open cattle stock water trough during warm weather and contained visible algae growth. The water was blended to ensure consistency and then 50 ml samples of the water were transferred to eighteen small beakers (two beakers per treatment). Prior to adding the test products to each beaker, initial aerobic bacterial, yeast and mold counts were determined using Petrifilm™. Products were added the appropriate beakers to achieve pH values of 4 and 6. Beakers were then held at room temperature uncovered and retested at 2 and 24 hours post treatment. Counts were converted to $\log_{10}$ values and statistically analyzed.

Results and Discussion

The initial aerobic bacterial counts before treatments were very high and almost identical for all treatments (Table 1). Consistently high counts were found in control samples at both 2 and 24 hours post treatment. Counts from citric acid (Russell), citric acid (food grade) and sodium bisulfate pH 6 were not significantly different from control at either sampling time. While a small (<1 log), but significant ($P<0.05$) decrease was observed in counts from sodium bisulfate pH 4 at 2 hours post treatment, no differences from control were found in this treatment at 24 hours. Only the acidified copper sulfate treatments (both pH 4 and 6) gave a significant ($P<0.05$) reduction of 2 logs or 99% at 2 hours and 24 hours post treatment. However, it is important to point out that log counts of greater than 4.0 mean that there are over 100,000 cfu/ml were still present in the water after treatment and that water system cleaning is strongly recommended when aerobic bacterial counts are 10,000 cfu/ml or higher.

Both yeast and mold counts from control samples increased slightly over the course of the trial (Table 2 and 3). This increase in counts may reflect that long-known fact that growth of the majority of yeast and mold species is favored by acid pH values (Frazier, 1967). No significant difference from control was found in yeast or mold counts from any treatment at 2 hours post-treatment. Only the acidified copper sulfate pH 4 treatment showed a small (<1 log) but significant (P<0.05) decrease in both yeast and mold counts at 24 hours post-treatment. While mold counts from acidified copper sulfate pH 6 and citric acid (food grade) pH 6 were significantly (P<0.05) reduced as compared to control, these differences were less than 0.25 log.

Conclusion

Drinking water quality continues to be an area of concern for poultry growers. Recently a company swabbed different areas of a drinker system including stand pipes, inside nipple drinkers and water hoses. They were shocked to find E. coli, Pseudomonas aeruginosa, Staphylococcus, and Klebsiella penumoniae. This confirms the fact that water systems can become breeding grounds for various disease organisms. Protecting the water system by cleaning with appropriate disinfectants and then establishing a daily water sanitation program is an excellent insurance program against water borne diseases. The results of this test further confirm that using acidifiers even at a pH of 4 are not enough to thoroughly kill all microbes when a water system is heavily loaded with microbial growth. Utilizing the wrong products to clean systems particularly on farms with a disease history can be a waste of time and money.

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Table 1. Effect of Common Acidifiers on Aerobic Bacterial Counts from Dirty Water.

Product	pH	Aerobic Bacterial Counts (Log_{10})		
		Pre-Treatment Counts	Post-Treatment 2 Hours	Post-Treatment 24 Hours
Control (Dirty Water)	7.94	6.68	6.62c	6.47b
Acidified Copper Sulfate	4	6.71	4.22a	4.15a
Acidified Copper Sulfate	6	6.62	4.49a	4.42a
Citric Acid (Food Grade)	4	6.88	6.75c	6.35b
Citric Acid (Food Grade)	6	6.60	6.52c	6.38b
Citric Acid (Russell)	4	6.71	6.48c	6.27b
Citric Acid (Russell)	6	6.71	6.71c	6.57b
Sodium Bisulfate	4	6.74	5.87b	6.17b
Sodium Bisulfate	6	6.69	6.52c	6.44b
SEM		.14	.18	.15
P Value		.9470	.0001	.0001

a,b,c Means in a column with different letters were different (P<0.05).

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Table 2. Effect of Common Acidifiers on Yeast Counts from Dirty Water.

Product	pH	Yeast Counts (Log_{10})		
		Pre-Treatment Counts	Post-Treatment 2 Hours	Post-Treatment 24 Hours
Control (Dirty Water)	7.94	4.37	4.66	4.66b
Acidified Copper Sulfate	4	4.34	4.17	4.03a
Acidified Copper Sulfate	6	4.34	4.31	4.57b
Citric Acid (Food Grade)	4	4.58	4.35	4.66b
Citric Acid (Food Grade)	6	4.37	4.24	4.49b
Citric Acid (Russell)	4	4.39	4.09	4.67b
Citric Acid (Russell)	6	4.29	4.52	4.60b
Sodium Bisulfate	4	4.37	4.25	4.48b
Sodium Bisulfate	6	4.30	4.50	4.57b
SEM		.33	.22	.06
P Value		.9995	.0929	.0013

a,b Means in a column with different letters were different ($P<0.05$).

Table 3. Effect of Common Acidifiers on Mold Counts from Dirty Water.

Product	pH	Mold Counts (Log_{10})		
		Pre-Treatment Counts	Post-Treatment 2 Hours	Post-Treatment 24 Hours
Control (Dirty Water)	7.95	3.16	3.69	3.53cd
Acidified Copper Sulfate	4	3.12	3.13	2.73a
Acidified Copper Sulfate	6	3.19	3.35	3.30b
Citric Acid (Food Grade)	4	3.34	3.42	3.48c
Citric Acid (Food Grade)	6	3.19	3.07	3.30b
Citric Acid (Russell)	4	3.15	3.08	3.65d
Citric Acid (Russell)	6	3.25	3.45	3.59cd
Sodium Bisulfate	4	3.37	2.85	3.48c
Sodium Bisulfate	6	3.30	3.47	3.65d
SEM		.37	.22	.049
P Value		.9998	.3371	.0001

a,b,c,d Means in a column with different letters were different ($P<0.05$).

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The Stress of Poultry Farming: Know How to Manage It

Introduction

It's a hot August afternoon; chickens sell in 2 days but one of the sump pumps on the cool cell system just burned out. You get to the chicken house at 5:30 am and the feed lines and hoppers are running empty because something in the feed has locked up the cross auger. Does this sound familiar – and stressful? Poultry farming can be a difficult, demanding, and stressful occupation. In fact, agriculture is one of the most stressful of all occupations. That's partly because farmers and their families must cope with many forces (e.g., weather, livestock disease, equipment breakdowns, etc.) that are beyond their control (Daniels, 2006). Thankfully, there are several things we can do to combat stress and live healthy and productive lives.

What is Stress?

Stress is a term that originated in the field of engineering, where it means a substance's capacity to withstand strain (Weigel, 1983). However, stress is more complex when applied to human beings. One of the simplest definitions of stress in humans is "a state of physical and emotional arousal that is brought on by a stressor," such as an equipment breakdown or a feed truck not delivering on time.

Stress is a normal part of everyone's life. It affects all human systems simultaneously. Stress can accelerate the aging process. Dr. Hans Selye refers to stress as the "sum total of wear and tear on the body." In fact, it is estimated that as many as 60 to 80 percent of doctor visits may be stress related.

However, not all stress is bad. Good stress is called eustress, and it can increase our motivation to do our best and be successful. Bad stress is called distress, and it can negatively affect our health (Reynolds, 2008). When bad stress builds up over a period of time it is called cumulative stress, and it can result in deteriorating performance, relationships, and health.

Know the Signs

Stress affects people in a variety of different ways and what is worrisome to one person may not seem like a big deal to another. But there are some common signs and symptoms of stress that everyone should be aware of. These symptoms fall into one of four categories, and it is not uncommon to experience multiple symptoms from multiple categories simultaneously (Walker & Walker, 1987):

1. Physical – Headaches, Ulcers, Backaches, Eating irregularities, Sleep disturbances, Frequent sickness, and Exhaustion
2. Emotional – Sadness, Depression, Bitterness, Anger, Anxiety, Loss of spirit, Loss of humor
3. Cognitive – Memory loss, Lack of concentration, Inability to make decisions
4. Behavioral – Irritability, Backbiting, Acting out, Withdrawal, Passive-aggressiveness, Substance abuse, Violence.

If you are experiencing one or more of these symptoms, it may be due to the stress in your life and the way you are handling it. If you are stressed, it may be wise to consult your physician and/or try the powerful stress relieving ideas mentioned later in this article. If you ignore these signs and symptoms of stress and let your stress levels go unchecked, a variety of

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potential problems may develop. Prolonged stress can lower the efficiency of your immune system, making you more susceptible to a wide range of illnesses (Walker and Walker, 1987). Also, be aware that many people under stress often forget about everyone else; becoming so wrapped up in their own problems that they start to snap at family and friends (Huhnke, 2007). Stress affects not only an individual, but everyone close to that individual.

Stress and Poultry Farming

Studies comparing people's stress levels and coping behavior found that stress levels of farmers were significantly higher than non-farmers (Pitzer, 1987). Problem areas for farmers under stress include depression, over-eating, excessive caffeine intake, lack of physical exercise, and a reluctance to seek professional help (Pitzer, 1987).

Farming is dangerous work, second only to the mining industry (National Safety Council, 2003). In 2003, 730 people died and 150,000 were permanently disabled by injuries sustained on farms and ranches in the United States (National Safety Council, 2003). The National Institute for Occupational Safety and Health found farm owners displayed a high incidence of stress-related diseases when compared to other occupations (Smith et al., 1977).

Many poultry producers work alone for extended periods and the work must get done even if that producer is sick or exhausted. This can increase stress levels and may affect concentration and safety practices. Producers should be aware of occupational hazards and avoid dangerous situations. Feed augers that can grab fingers and clothing, spinning fan blades, electrical motors, and feed bin ladders are only a few of the dangers poultry producers face on a daily basis.

Equipment breakdowns can increase stress levels as well. When this happens, it is best to just relax, take a couple of deep breaths and assess the situation. This can be difficult to do, especially when you are in a hurry to fix the problem. However, if you think through your strategy beforehand you can improve your thought process and get more done in less time.

Stress and Gender

Stress affects both men and women, but it may be even greater for farm women. That's because they may experience additional stressors compared to their male counterparts. Many farm women have full responsibility for household tasks (which often go unnoticed) in addition to being a full partner in the farm business or holding down an off-farm job (Reynolds, 2008). Fortunately, there are several organizations that offer support and assistance for women in agriculture. Arkansas Women in Agriculture is a private nonprofit organization that: 1. provides educational programs for women involved in agriculture in Arkansas, 2. provides a network with other Arkansas women involved in agricultural community issues, and 3. identifies new ways to balance the demands of family, community and professional life. Other national organizations such as Women in Blue Jeans and Women in Denim have similar purposes. Programs such as Annie's Project seek to address the challenges that women face as farm owners and business partners in agricultural operations, and arm them with the tools to succeed in their operations.

General stresses that women experience in society may be particularly acute for women in male-dominated fields such as agriculture. These stresses include agricultural stereotypes, women's lack of perceived authority for farm management, gender roles and stereotypes at home and in public, and lack of access to agricultural programs and loans (Reynolds, 2008).

Managing Stress and Living Well

Three of the best things anyone can do to manage the stress in their life and live healthier include: 1. Eating sensible amounts of healthy food (and eating regular meals), 2. Participating in some type of physical activity at least 30 minutes a day 5-6 times a week, and 3. Going to bed and waking up at about the same time every day, allowing for 7-8 hrs. of sleep. A well managed diet, regular exercise, and adequate sleep are proven strategies for fighting stress and depression.

In addition to the ideas mentioned above, there are several more proven ways to lower stress and live better. The science of happiness and well-being has progressed enough that we have identified seven things all of us can do that will improve the quality of our lives. The healthier and happier we are, the better we will be able to function. The University of Arkansas Cooperative Extension Service has summarized these seven keys of well-being in a publication called The Personal Journey (Goddard & Marshall, 2006).

1. **Enjoy today** - In the hike of life, we can focus on the obstacles along the trail or the beauty that surrounds us. Those who find the beauty in daily life travel well. The old adage is true--happiness comes from wanting what you get more than getting what you want. We are more likely to be happy when we think about all the good things in our lives rather than worrying about all the things we wish we had.

2. **Find the gems in your past** - Anyone who wants to find a gem must be willing to search for it. Likewise, we find treasures in our life stories when we are willing to dig through challenges and disappointments to find them. Those who find and cherish the gems in their past are those who live the best lives. Some gems jump right out at us, but others take some time to find and to polish. Quite often, today's gems were yesterday's trials and difficulties. It is only through the lens of our personal growth and perspective that we can now see diamonds in what we once thought were ugly lumps of coal. Most of us have had disappointment and pain in our life histories and they sometimes burden us. They may even affect how we see ourselves and our lives. One of the surprising discoveries of modern psychology is that bad events in our past (childhood) don't have to lead to or cause a bad adult life. We need not be held hostage to our past. We can "rewrite our

history with forgiveness" - that is, we can go back through the bad experiences of our lives and offer compassion and understanding to those who hurt us. We can also choose to find the good in our past and emphasize that. We can celebrate our own abilities to survive and thrive in an imperfect world.

3. **Look forward to tomorrow** - People who are excited and hopeful about the future are likely to have better journeys. Those who look for and expect to find good things usually do. Who knows what great things will happen tomorrow! Some of us look to the future with anxiety and apprehension. We worry about what may or may not happen. Constant worrying isn't good for the human soul. People who have a steady optimism are more likely to thrive than those who worry and fret.

4. **Use your strengths** - Each person has strengths and weaknesses. The greatest joy and progress come from using our strengths while managing our weaknesses. We discover our strengths by noticing what we love to do-those things that challenge us and get us so engaged that we lose track of time. Many of us fret endlessly about our weaknesses. We regularly come up with self-improvement programs to overcome this weakness, but these efforts may not be very productive. Psychologist Martin Seligman (2002) has said that we shouldn't devote too much energy to correcting our weaknesses. Rather, he believes that the highest success in living and the deepest emotional satisfaction comes from building on and using our signature strengths.

5. **Choose to serve** - Psychologists have found that people who use their strengths and abilities to make the world a better place are happier than those who don't. When we focus primarily on our selves our view of the world is narrow and limited. As we turn more energy and attention to helping others, the meaning and satisfaction of our own lives expand. There are countless places and ways we can serve others.

6. **Choose to grow** - Growth is the surest sign of progress in life. Seeking new ideas, experiences, and projects helps us grow and enjoy our journey. When we challenge ourselves to keep reading, listening, and learning, our lives are more full and rich. Happiness is a way of traveling more than a place to go. When we travel the trails of life eager to learn and grow, we will travel well.

7. **Don't Forget Your Compass!** - Each of us is equipped with a personal compass-or conscience-to guide us along life's journey. Conscience is the peaceful voice inside of us that invites us to be compassionate, kind, and honorable. When we ignore the compass, we get lost. When we use our compass well, our journey will be richer and more meaningful.

Try the principles described above and see if they don't decrease the stress you feel and increase the light and energy in your life!

Summary and Conclusions

Poultry farming is a stressful occupation (e.g., heat in summer, high fuel bills in winter, disease outbreaks, equipment breakdowns, etc.) and many farmers push themselves too hard. But just because stress is an unavoidable part of farming does not mean it is unmanageable.

Proven techniques can help reduce stress and make our lives happier as well as more productive. Many of you may already be excellent in most of the areas mentioned. Celebrate the parts of your life that are satisfying! If there is an area where you would like to do better, make a plan. We wish you happiness in your personal journey!

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Water: Identifying and Correcting Challenges

INTRODUCTION

The value of a clean, safe water supply is often overlooked in poultry production. Water tests performed by a reputable lab can be a valuable tool for identifying the source of performance problems. On-farm tests can also be helpful for monitoring and improving water quality. The following information was prepared as a guideline for interpreting poultry drinking water quality test results along with guidelines for commonly used correction options.

Chlorine is the cheapest water sanitizer available and it works well, but other products such as chlorine dioxide and hydrogen peroxide are also available and used successfully.

BACTERIA TEST

The established guidelines for poultry drinking water quality are outlined in Table 1. Note that CFU/ml means colony-forming units of bacteria/milliliter of water, and mg/liter is the same as parts per million or ppm. The test results received from some labs are labeled Total Plate Count (TPC) of aerobic (oxygen loving) bacteria as measured by CFU/ml. These results do not indicate whether the bacteria present is harmful (pathogenic) or harmless, but it can indicate if the system is dirty and therefore at risk for the presence of harmful bacteria. If the TPC level is 1000 CFU/ml or less then the water supply is considered acceptable. However, the goal should be 0 CFU/ml even when the sample is pulled from the end of the drinker line. The closer water microbial results are to 0 CFU/ml, the better the water supply is for the commercial poultry production. Should the test results be greater than 10,000 CFU/ml, it is strongly recommended that the water system be thoroughly cleaned between flocks with an approved cleaner. After line cleaning, implement a consistent daily water sanitation program while birds are present.

Chlorine is the cheapest water sanitizer available and it works well, but other products such as chlorine dioxide and hydrogen peroxide are also available and used successfully. Drinking water target levels of free chlorine are 2-4 ppm, for chlorine dioxide the desired level is 0.8 ppm and for hydrogen peroxide, it is 25-50 ppm. (Table 2). Factors such as turbidity (suspended solids in the water; water actually looks dirty) minerals and organic material which is often present in surface water supplies will greatly influence how effective sanitizers work. In addition, the dirtier the water, the more likely there will be taste issues associated with the use of chlorine. It is possible to see birds backing off water due to presence of high levels of chlorine, mainly when it is in the bleach form since bleach or sodium hypochlorite will have a bitter taste associated with it. When it becomes necessary to use more and more chlorine to get a 2-4 ppm free chlorine reading, then it is strongly recommended that the water be tested and a professional water treatment system installed. Chlorine dioxide and hydrogen peroxide are less likely to cause taste issues and are therefore good alternatives when treating some water supplies such as pond or river water supplies.

If the water test is performed by the Department of Health, the results are total coliforms. There are actually two types of coliform counts that may be reported. **Total** colform counts detect bacteria that can be found in many locations including feces, but **fecal** coliform counts detect bacteria that are found only in human or animal feces. Coliforms are a good indicator organism for potential contamination by livestock (runoff from concentrated animal production areas) or human waste (failed septic system). If total coliform counts are more than 50 cfu/ml and/or any fecal coliforms are detected, it is recommended that the well be shock chlorinated. However, shock chlorination can only be done to the water supply between flocks since the high level of chlorine is not suitable for consumption by humans or animals. In addition, look for possible sources of contamination and correct the problem to prevent recontamination.

Never assume that water quality remains good through poultry house water systems. When in doubt, test the water at the source and at the end of the line. Results from previous water tests (Table 3) show just how dramatically water quality can change even over the course of a few hundred feet.

Water supplies should be tested if there is:
• A noticeable change in color, odor or taste,
• Any flooding near the well,
• A person or animal that becomes sick from waterborne disease,
• Maintenance on water supply system,
• Persistent poor flock performance or
• A loss of pressure in water system (Langston, 1994).

MINERAL TESTS

Pure water does not exist as drinking water. All water supplies have some amount of dissolved minerals or contaminants as they are referred to by EPA. In many cases the contaminants are within acceptable ranges, cause no problems and may even be desirable. However contaminants present at unacceptable levels can potentially be linked to the following issues:

1) Poor performance,
2) Equipment failure or damage or
3) Presence of harmful bacteria or fungal slime (some minerals serve as a food supply).

Information in Table 1 is listed as parts per million or milligrams per liter which is the same. Although ppm is a small amount, it is important to remember, the birds already receive a balanced diet and if they are also receiving high levels of such nutrients as salt in the water, in the form of sodium and chloride ions, then the birds may exhibit poor performance because they just have more than their systems can handle. In addition, several water contaminants such as iron and calcium can also impact how the drinker system functions. Even a fine buildup of mineral residue on seals or rims could be all that is necessary to limit water flow and thus result in less than adequate consumption for optimum bird growth and feed conversion.

ON FARM WATER TESTS

While laboratory water tests provide valuable information, time is required for samples to be analyzed and critical decisions might be delayed. A good deal of valuable information can be collected on sight using test kits or meters. This information can provide producers with a quick "score card" of how they are doing with respect to water quality. However, it is important to remember not to base major decisions on a single test. Two to three tests yielding similar results on similar samples will provide a more solid basis for decisions.

• Oxidation-Reduction Potential (ORP) Meters

When developing water sanitation programs one tool which has proven useful in assuring that water has optimum sanitizing value and quality for the birds is Oxidation Reduction Potential or ORP. ORP simply refers to the property of oxidizing sanitizers such as chlorine to be their most effective. A strong oxidizer literally burns up viruses, bacteria and other organic material present leaving water microbiologically safe. An ORP value in the range of 650 millivolts (mV) or greater indicates good quality water that can be effectively sanitized by as little as 2-4 ppm free chlorine. The lower the value such as 250 mV indicates a heavy organic load or the presence of reducing agents such as ferrous iron, (Fe^{2+}), manganese (Mn^{2+}), bisulfide (HS^{-}) and sulfite. Naturally occurring oxidizing elements in the water such as oxygen and sulfur along with chlorine and chromate can give increased ORP readings but it is usually only a good sanitizing residual at a favorable pH (5-7) that gives the most desirable ORP readings of 700-750 mV. The ORP meter can be a useful tool for identifying water supplies that don't have adequate chlorine residual and for adjusting the residual without overusing chlorine. A reliable ORP meter costs around $100 and can be purchased from Hanna Instruments, Hach or Grainger.

• Chlorine Testing Kits

Chlorine test kits come in a variety of formats. The format is not as important as what is detected. Most inexpensive chlorine test kits (such as pool test kits) detect both free and total chlorine. Total chlorine does not distinguish between the chlorine that is bound and free or available chlorine. Only free chlorine is capable of water disinfection. A heavy organic load in it would result in a greater percentage of bound chlorine resulting in a poor sanitizer and possibly bad taste issues (decreased water consumption) even though the pool test kit might indicate total chlorine levels of 4 to 6 ppm. Therefore, be certain that the test kit detects free chlorine and that levels are 2 to 4 ppm.

• pH Testing Kits

Kits for testing water pH are generally inexpensive and somewhat reliable. Birds are very tolerant of pH 2-3 for short periods, (2-3 days) and they are very tolerant of pH 4 to 8 on a continuous basis. Water sanitizers (chlorine, chlorine dioxide or hydrogen peroxide) generally work better when pH values are between 5.5 and 7. There is concern that some forms of strong acids (muriatic or phosphoric) or low pH (2-3) can actually damage drinker equipment so before beginning any water acidification program, check the manufacturer's recommendations.

• Using Test Information

The bottom line: utilize information on pH, ORP and chlorine level to determine if the sanitation program is effective and to prevent equipment damage by the overuse of

WATER CHALLENGES — continued on page 12

chemicals. It may also be valuable to record and retain the information collected so that trends can be seen.

WATER SANITATION

Successful water sanitation programs start with a clean system. Once clean, there are several options for maintaining a clean system and providing birds with water that has sanitizing residual. These include chlorine, chlorine dioxide and hydrogen peroxide. Ozone systems are also used on poultry farms, but can be expensive to install for water sanitation alone. Iodine has also been used successfully as a daily water sanitizer. The guidelines in Table 2 can help growers assure they have adequate sanitizer present.

WATER TREATMENTS

Table 1 provides information on treatment options when contaminants are found at unacceptable levels. While there are many available treatment options, this section covers some of the basic treatments concepts. Before investing in any technology for water treatment, talk with a reputable water equipment dealer to assure the investment will fix your water quality issues.

• Filtration

Water has many categories of impurities. Filtration's purpose is to reduce or remove the solid particulates and microorganisms from the water. Dissolved impurities can pass through filters. Think of it as filtering tea. The tea will taste the same before and after the filter but the tea leaves will be trapped by the filter. The benefits of reduced particulates and microorganisms in water on a poultry farm are several. Filtered water means that the drinker nipples do not clog or drip so the birds get water but the litter under the drinkers remains dry. This means, of course, that flocks grow rapidly due to increased hydration and fewer pathogens in the litter. Filtered water means less frequent clogs and better operation of evaporative cooling systems and therefore a healthier environment for the flock.

When used in conjunction with oxidation (described below) filtration can remove can remove dissolved minerals. Oxidation causes dissolved minerals to precipitate (settle) out, leading to higher particulate loads and problems with water lines, drinkers and cooling systems. However, when water is filtered after oxidation, particles and minerals are removed.

The retention of particles and microorganisms on filters is measured in microns. A micron is one millionth of a meter. A good reference point is 40 microns, which is the smallest particle the average human eye can see under optimal light conditions. The standard retention level for poultry house water systems is 20 microns. By far, the most common filter employed on poultry farms is the 10" long wound filter. While the filters are rated for 20 micron retention, they generally only retain 50% of the 20 micron particles, and that is only when a flow rate of 2 gallons per minute or less is passed through them. Higher flows cause channeling, where the water separates the windings and particles are pushed through. Also, these filters do not seal well to the filter housings which can results in by-pass flow around the ends of the filters. To eliminate these problems, filters with o-ring seals and filter medias that retain 95% of the stated micron rating should be used (Hammond, 2008).

• Oxidation

Oxidation is the process of reacting soluble minerals such as iron, manganese and sulfur with an oxidizer such as chlorine, ozone or chlorine dioxide or even air to create an insoluble particle that can be filtered from the water. One requirement for proper oxidation is to allow adequate time for the "oxidizers" to react with the minerals. To oxidize iron requires above 7 pH and a minimum or 20 minutes reaction time while manganese needs above 8 pH and much longer reaction time.

• Water Softener

Water softeners are useful for removing calcium and magnesium as well as soluble iron and manganese. Water passes through a synthetic material or resin called zeolite where sodium is traded for these minerals. Sodium ions must be periodically replaced by flushing the softener tank with a solution of sodium chloride (salt). Most water softeners do not tolerate oxidized iron or manganese or iron bacteria. These must be removed first. If the water is cloudy, then some of the contaminants are not dissolved and must be removed first before the water softener.

• Aeration

Aerating water can be effective for removing hydrogen sulfide, reducing dissolved carbon dioxide as well as oxidizing iron and manganese. This can be accomplished by pumping water into holding tank and allowing the water to fall into the tank like a waterfall instead of pumping water into a holding tank from the bottom.

• Reverse Osmosis

Reverse osmosis (RO) is the most common option for reducing sodium, chloride and nitrates in water. In reverse osmosis, the water is forced by high pressure through a series of membranes. Water must be pre-treated to remove calcium, magnesium iron and manganese prior to the RO system. RO treated water can be aggressive or damaging to metal pipes and fittings.

CONCLUSION

In conclusion, water is one of the most essential nutrient birds receive, yet the quality of bird drinking water is often taken for granted. Providing flocks with a clean, wholesome supply can make a difference in performance. Should water be a suspect for flock problems, make arrangements to have water tested for total bacteria numbers as well as for mineral content. While total aerobic plate count won't tell exactly what is in the water, it is an indicator of excessive levels of bacteria that should be addressed. By promoting a regular water sanitation program on farm, producers can prevent environments in water systems that could lead to poor bird performance. Also understanding what types of chemical contaminants are present and addressing those that are known to cause poor performance can help growers improve their bottom line.

WATER CHALLENGES — continued on page 14

Table 1. Water Quality Standards and Treatment Options.

Water Quality Indicator	Levels considered average	Maximum Acceptable Level	Maximum Acceptable Levels Indicate	Treatment Options/ Comments
Total Bacteria (TPC) Total Coliforms Fecal Coliforms	0 CFU/ml 0 CFU/ml 0 CFU/ml	1000 CFU/ml 50 CFU/ml 0 CFU/ml	• Dirty system, may taste bad and COULD have pathogens in the water system • Water with >50 total coliforms or any fecal coliform has been in contact with human or animal feces	• Clean the system between flocks with approved sanitizing cleaners and establish a daily water sanitation system when birds are present • Shock chlorinate as well
pH	6.5 - 7.8	5-8	• below 5 - metal corrosion • above 8 - Water sanitizers work poorly, "bitter" taste	• Raise pH with soda ash (Na_2CO_3), lime Ca $(OH)_2$ or sodium hydorxide (NaOH) • Lover pH-phosphoric acid, sulfuric acid and hydrochloric acid for strong alkalinity, citric acid and vinegar for weak alkilinity
Alkalinity	100 mg/l	300 mg/l	• Associated with bicarbonate, sulfates and calcium carbonate • Can give water a bitter taste which makes it undesireable to the birds • High levels can make it difficult to lower the pH • Can be corrosive to cool cell pads	• Acidification • ANION Exchange dealkalizer • Can be reduced by removing free CO_2 (carbon dioxide) through aeration
Total Hardness	Soft 0 - 75mg/l as $CaCO_2$ Somewhat hard 76 to 150 Hard 151 to 300 Very Hard >300		• Hardness causes scale which reduces pipe vlume and drinkers hard are to trigger or leak (main factors are calcium and magnesium, but iron and manganese contribute small amount)	• Do not use water softener if water already high in sodium unless using potassium chloride instead of sodium chloride (salt) • Polyphosphates will sequester or tie-up hardness and keep in solution • Acidification to below pH of 6.5
Calcium (Ca)	60 mg/l		• No upper limit for calcium, but if values are above 110 mg/l may cause scaling	• Treatment same for hardness
Magnesium (Mg)	14 mg/l	125 mg/l	• May cause flushing due to laxative effect particularly if high sulfate present	• Treatment same for hardness
Iron (Fe)	.2 mg/l	0.3 mg/l	• Birds tolerant of metallic taste • Iron deposits in drinkers may cause leaking • Can promote growth of bacteria such as *E. Coli* and *Pseudomonas*	• Treatment includes addition of one of the following:chlorine, chlorine dioxide or ozone then filtration removal with proper sized mechanical filtration
Manganese	0.01 mg/l	0.05 mg/l	• Can result in black grainy residue on filters and in drinkers	• Similar to iron but can be more difficult to remove due to slow reaction time • Chlorination followed by filtration most effective in pH range of 8.5, needs extended contact time with chlorine prior to filtration unless using Iron X media • Ion exchange resin if pH is 6.8 or above • Greensand filters with pH above 8.0
Chloride (Cl)	50 mg/l	150 mg/l	• Combined with high Na levels, can cause flushing and enteric issues • Can promote Enteroccoci bacterial growth	• Reverse Osmosis, blend with non-saline water, keep water clean and use daily sanitizers such as hydrogen peroxide or iodine to prevent microbial growth
Sodium (Na)	50 mg/l	150 mg/l	• With high Cl levels can cause flushing • Can promote Enteroccoci bacterial growth	• Reverse Osmosis • Blend with non-saline water, • Keep water clean and use daily sanitizers such as hydrogen peroxide or iodine to prevent microbial growth

TABLE 1 — continued on page 15

Table 1. continued.

Water Quality Indicator	Levels considered average	Maximum Acceptable Level	Maximum Acceptable Levels Indicate	Treatment Options/ Comments
Sulfates	15 - 40 mg/l	200 mg/l	• Sulfates can cause flushing in birds • Rotten egg smell is hydrogen sulfide, by-product of sulfur loving bacteria growth - this can cause air locks in water system as well as flushing in birds • Since sulfides can gas off, test results may underestimate actual level present	• Aerate water into a holding tank to gas off sulfur • Anion exchange (chloride based) • Treatment with oxidizing sanitizers then filtration • If a rotten egg odor is present, shock chlorination of well is recommended plus a good daily water sanitation program while birds are present
Nitrates	1 - 5 mg/l	25 mg/l	• Poor growth and feed conversions • May indicate fecal contamination, test for coliform bacteria	• Reverse Osmosis • Anion exchange
Lead	0 mg/l	0.05 mg/l	• Can cause weak bones and fertility problems in broiler or turkey breeders	• Lead is not naturally occurring. Look for pipes, fittings or solder that contain lead • Water softeners and activated carbon can reduce lead
Copper	0.002 mg/l	0.6 mg/l	• High levels can cause oral lesions or gizzard erosion	• Source is most likely from the corrosion of pipes or fittings
Zinc		1.5 mg/l	• Higher levels may reduce growth rates	• Look for locations where water may have come in contact with galvanized containers • Water softener and activated carbon will reduce adsorption

Table 2. Suggested Sanitizer Levels in Poultry Drinking Water with Birds in the House.

Sanitizer	Suggested residual level in the drinking water (ppm)	Comments
Chlorine	2-4 ppm free chlorine	Chlorine is most effective in 5-7 pH range Total chlorine test does not separate the bound chlorine from the free or available chlorine
Chlorine dioxide	0.8 ppm	Effective over a wide pH range 4-9 but does work best in pH range of 4-7
Hydrogen peroxide	25 - 50 ppm	Hydrogen peroxide works well when injected after ozone treatment

Table 3. Examples of Aerobic Bacteria Levels Found in Poultry Drinking Water Sources.

Farm	Sample Location	CFU/ml
A	At the well	2,700
A	End of drinker line in poultry barn	26,600
B	At source (community water line)	203,000
B	End of drinker line in poultry barn	2,340,000
C	At the well	600
C	End of drinker line in poultry barn	282,000
D	At the well	0
D	End of drinker line in poultry barn	4,775,000

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